PATENT ABSTRACTS OF JAPAN

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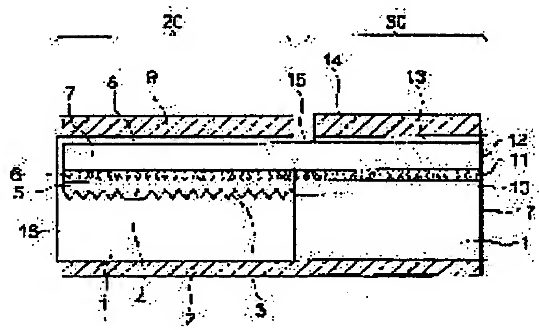
(72)Inventor : ISHIZAKA MASASHIGE

(54) MODULATOR INTEGRATED LIGHT SOURCE AND MODULE FOR OPTICAL COMMUNICATION

(57)Abstract:
PROBLEM TO BE SOLVED: To increase the whole yield of a modulator integrated light source with the asymmetric λ/4 phase shift range of which a semiconductor of distribution feedback type and a modulator of light absorbing type are integrated on the same substrate and to reduce the cost of its manufacture.
SOLUTION: This modulator integrated power source is provided with a semiconductor laser of distribution feedback type 20 and a modulator of light absorption type 30, which are formed on the same n-InP substrate 1. The relationship between the κL value of a diffraction grating 3 with a phase shift range 4 and the reflectance is selected to maximize the yield of the integrated power source. κL value is selected within the range of 1 to 1.2 in the case the reflectance R is between 0.01 and 0.02%, while κL value is selected larger as the reflectance R gets larger.



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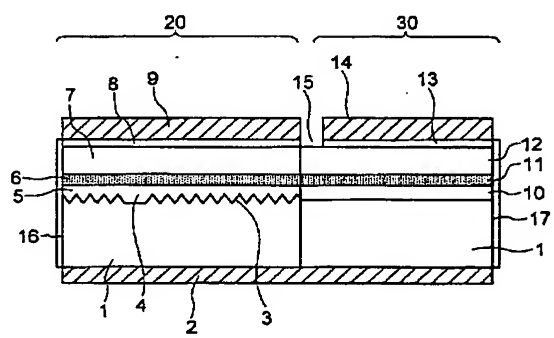
(54)【発明の名称】　変調器集積化光源及び光通信用モジュール

(57)【要約】

【課題】　分布帰還型半導体レーザと光吸収型変調器とを同一基板上に集積した非対称λ／４位相シフト領域付き変調器集積化電源の全歩留まりを高め、製造コストを低減する。

【解決手段】　変調器集積化電源は、分布帰還型半導体レーザ２０と、光吸収型変調器３０とを同一のｎ－ＩｎＰ基板１上に形成し、位相シフト領域４を有する回折格子３のκＬ値と、変調器３０の光出射側端面の反射率との関係を、集積化電源の歩留まりを最大にするように選定している。例えば反射率Ｒが０．０１～０．０２％の場合には、κＬ値を１～１．２の範囲に選定し、反射率が高くなるとそれに応じてκＬ値を高くする。



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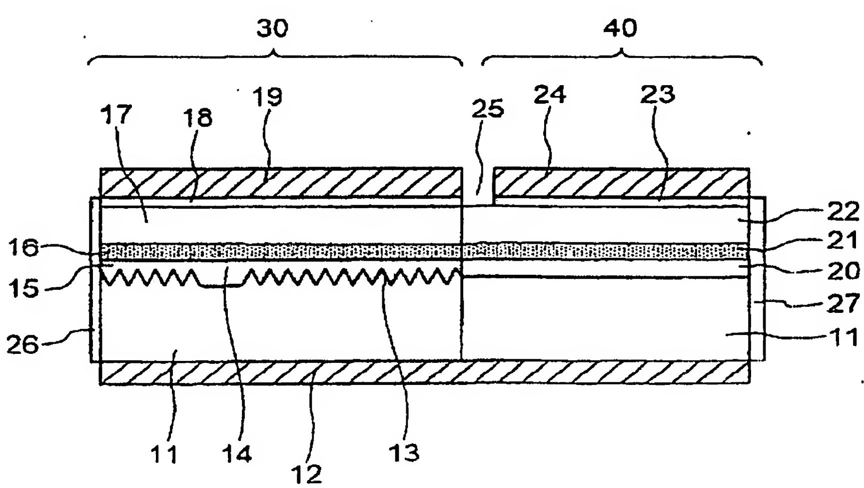
(54) Light source containing a distributed feedback laser and an integrated optical modulator

(57) An optical device including: a substrate (11); a distributed feedback (DFB) semiconductor laser (30) formed on the substrate (11) and including a diffraction grating (13) having an asymmetrical λ/4 phase shift region (14), the diffraction grating (13) extending along an optical axis of the DFB semiconductor laser (30); and a field absorbing modulator (40) integrated with the DFB semiconductor laser (30) on the substrate (11) for modulating a light wave emitted from the DFB semiconductor laser (30) characterized in that: the modulator (40) has a facet reflection rate between 0.01 and 0.02 % at an output end thereof, and the diffraction grating (13) has a κ L value between 1 and 1.2. The proper combinations of the κ L value of the diffraction grating (13) and the reflection rate of the output facet of the modulator (40)of the DEB semiconductor laser (30) can fabricate the source for integrating the modulator (40) having the excellent quality with a higher yield and lower cost.

FIG. 2



EP 1 154 533 A1

Description

BACKGROUND OF THE INVENTION

(a) Field of the Invention

[0001] The present invention relates to a light source integrated with a modulator and a module for optical communication, and especially to the structure for the light source integrated with the modulator and suitable for a light source for long distance trunk used in wavelength division multiplexing (WDM).

(b) Description of the Related Art

[0002] As a light source for long distance trunk used in WDM, a module is put into practice which includes a distributed feedback semiconductor laser (DFB-LD) and a field absorbing modulator (MOD) on a single semiconductor substrate. This type of light source can realizes the transmission speed as high as 2.5 Gb/s and has been vigorously researched.

[0003] A resistance to distribution or an ability of transmitting long-distance signals in the DFB-LD is the most important parameter exhibiting element performance. The selection of products having no defect therein is currently conducted by measuring the resistance to distribution or the power penalty after the transmission of each element. It is an important subject to increase the yield of the selection for decreasing the cost of the light source.

[0004] Murotani et al. reported the dependency of the single mode yield of the DFB/MOD module having an asymmetrical λ/4 phase shifter (a structure obtained by moving the λ/4 phase shift region of the diffraction grating from the central position of the DFB-LD, hereinafter referred to as "asymmetrical λ/4-DFB/MOD") on a κ L value of a diffraction grating in the DFB-LD in the Electronics Society Meeting (C-4-15, p242) held in September 1999 by the Institute of Electronics, Information and Communication Engineers.

[0005] As shown in Fig.1, the single mode yield rapidly decreases with the increase of the κ L in the asymmetrical λ/4-DFB/MOD module. Conventional publications including the above publication describe neither the yield of the power source integrated with the modulator separately from the single mode yield, nor the optimum structure regarding determination of the facet reflection rate and of the κ L. The optimum structure has not been conventionally established by considering the dependency of the diffraction grating on the κ L value and the dependency of the modulator on the facet reflection rate.

SUMMARY OF THE INVENTION

[0006] In view of the foregoing, an object of the present invention is to increase the yield of obtaining DFB/MOD module having no defect by considering the dependency of the κL value of the diffraction grating on the single mode yield and the transmission yield and the dependency of the modulator on the facet reflection rate.

[0007] The present invention provides an optical device including: a substrate; a distributed feedback (DFB) semiconductor laser formed on the substrate and including a diffraction grating having an asymmetrical λ/4 phase shift region, the diffraction grating extending along an optical axis of the DFB semiconductor laser; and a field absorbing modulator integrated with the DFB semiconductor laser on the substrate for modulating a light wave emitted from the DFB semiconductor laser, the modulator having a facet reflection rate between 0.01 and 0.02 % at an output end thereof, the diffraction grating having a κL value between 1.4 and 1.7.

[0008] In another aspect of the present invention, the facet reflection rate of the output end of the modulator is in a range between 0.02 and 0.03 %, and the κL value of the diffraction grating is between 1.2 and 1.3.

[0009] In a further aspect of the present invention, the facet reflection rate of the output end of the modulator is in a range between 0.03 and 0.05 %, and the κL value of the diffraction grating is between 1.3 and 1.4.

[0010] In a still further aspect of the present invention, the facet reflection rate of the output end of the modulator is in a range between 0.05 and 0.1 %, and the κL value of the diffraction grating is between 1.4 and 1.7.

[0011] In accordance with the present invention, the proper combinations of the κL value of the diffraction grating and the reflection rate of the output facet of the modulator of the DFB semiconductor laser can fabricate the source for integrating the modulator having the excellent quality with a higher yield and lower cost.

[0012] The above and other objects, features and advantages of the present invention will be more apparent from the following description.

BRIEF DESCRIPTION OF DRAWINGS

[0013] Fig.1 is a graph showing a relation between a κL value of a diffraction grating and a single mode yield.

[0014] Fig.2 is a vertical sectional view showing a source for integrating a modulator in accordance with a first embodiment of the present invention.

[0015] Fig.3 is a graph showing chirping wave-shapes which change depending on each of the combinations of both the facets of the source for integrating the modulator of Fig.2.

[0016] Fig.4 is a wave-shape diagram of a signal voltage applied to the modulator during measurement of the chirping.

[0017] Fig.5 is a graph showing a relation between a κL value of a diffraction grating and a transmission yield.

[0018] Fig.6 is a graph showing a relation between the κL value of the diffraction grating and the transmission

yield using, as a parameter, the reflection rate of the output facet of the modulator.

[0019] Fig.7 is a graph showing a relation between the □L value of the diffraction grating and all the yield using, as a parameter, the reflection rate of the output facet of the modulator.

[0020] Fig.8 is a top plan view showing a resonator module in accordance with a second embodiment of the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

[0021] Then, the configuration of a light source for integrating a modulator of a first embodiment will be described referring to Fig.2.

[0022] As shown therein, a distributed feedback semiconductor laser (DFB-LD) 30 and a field absorbing modulator (MOD) 40 are integrated together on a single semiconductor substrate. A diffraction grating 13 having a space period of 2400 Å formed in a direction of progress of light and a flat phase shifting region 14 having a length of λ g/4 are formed on an n-InP substrate 11 by using, for example, an electron-beam exposure method or a chemical etching method. The phase shifting region 14 is disposed in the diffraction grating 13 such that the ratio between distances from the rear facet and the front facet (the emission end of the semiconductor laser) to the phase shifting region is 0.3 : 0.7. Then, an n-InGaAsP optical guide layer 15 having a wavelength of 1.15 μm, an undoped InGaAsP active layer 16 having a wavelength of 1.55 μm, a p-Inp cladding layer 17 and a p^+-InGaAs cap layer 18 are sequentially and epitaxially grown. Further, an n-InGaAsP buffer layer 20, an undoped InGaAsP light-absorbing layer 21, a p-InP cladding layer 22, and a p^+-InGaAs cap layer 23 are sequentially and epitaxially stacked onto the same n-InP substrate 11 by using a selective MOVPE (Metal Organic Vapor Phase Epitaxy) method or a pad joint method.

[0023] Then, a trench 25 is formed by using an ordinal etching method for electrically isolating the modulator 40 and the DFB laser 30. An n-type electrode 12 and p-type electrodes 14 and 19 are formed on the multi-layered semiconductor obtained in this manner. Finally, an AR (anti-reflection) coat film 27 is formed on the facet of the modulator 40, and an HR (higher reflection) coat film 26 is formed on the facet of the DFB-LD 30, thereby providing the configuration of the light source integrated with the modulator of the embodiment. The reflection rate of the light-emitting facet of the modulator 40 (optical power reflection rate) is 0.01 %, and the □L value of the diffraction grating 13 of the DFB laser 30 is established between 1 and 1.2, wherein "□" is a mode coupling constant, and "L" is a cavity length of the DFB laser.

[0024] Under the condition of continuously emitting light by the semiconductor laser at an operation current of 70 mA, a pulse voltage shown in Fig.4 was applied between the electrodes 23 and 12 of the modulator 40 to obtain the simulated change of the laser emission frequencies (chirping) as shown in Fig.3 by using a simulation. A plurality of curves in Fig.3 were formed depending on the combinations of the optical phases at both the facets of the light source integrated with the modulator. It can be seen from Fig.3 that the change of the combination of the optical phases at both the ends significantly changes its chirping. However, the excellent chirping can be hardly obtained if the combination of the phases at both the ends is determined by simply selecting the cavity length of the semiconductor laser.

[0025] The chirping is a main factor dominating the transmission performance, and the degree of the chirping is changed depending on the combination of the facet phases. The combination of the front and rear facet phases differs from the combination of another element, and has randomness substantially uncontrollable. Among the facet phases randomly occurring, the ratio of the facet phases generating the chirping in a permitted range exhibits the transmission yield.

[0026] A graph of Fig.5 shows the chirping from peak to peak (Δfpp), wherein simulated results (a curve 101 in the graph) of the transmission yields were obtained, and results by the actual measurement (dots 102 in the graph) were obtained under the situation that the product having the Δfpp 2.5 GHz was judged to be good quality. It can be seen from the graph of Fig.5 that the simulated results and the actual results were in excellent agreement, and the transmission yield increased with the increase of the □L value of the diffraction grating. The results are illustrated in Fig.6 which were obtained by the simulation and show the dependency of the transmission yield on the □L value and the reflection rate (R) of the modulator facet. As shown in the graph, the reduction of the reflection rate (R) increases the transmission yield.

[0027] The dependency of the single mode yield which is another main factor of increasing the yield on the □L value was measured and summarized in Fig.1.

[0028] All the yield changes depending on the above two main factors are shown in Fig.7, that is, the dependency of all the yields obtained by the single mode yield and the transmission yield on the □L value of the diffraction grating and the reflection rate of the modulator facet. Although only part of the reflection rates are shown in Fig.7 for facilitating the understanding, other various curves corresponding to the remaining reflection rates were obtained based on the simulations shown in Figs. 1 and 6 and actual measurements. It can be understood from Figs.6 and 7 that the proper selection of the □L value and the facet reflection rate can obtain the maximum yield. For example, the maximum yield can generally be obtained in the κL value range between 1 and 1.2 when the facet reflection rate (R) is 0.01 %, and can be obtained in the κL value range between 1.4 and 1.7 when the facet reflection rate (R) is 0.1 %.

[0029] The κL value range realizing the maximum yield of the integrated source was established with re-

spect to each of the facet reflection rates of the modulator based on the combinations of the points obtained in Figs.1 and 6. The κL value range is between 1.0 and 1.2 when the reflection rate is between 0.01 and 0.02 %, the κL value range is between 1.2 and 1.3 when the reflection rate is between 0.02 and 0.03 %, the κ L value range is between 1.3 and 1.4 when the reflection rate is between 0.03 and 0.05 %, and the κ L value range is between 1.4 and 1.7 when the reflection rate is between 0.05 and 0.1 %. In this manner, the all the maximum yields of the integrated source can be obtained by the combinations of the proper κ L value and the reflection rate.

[0030] Then, the configuration of a modulator module for optical communication of a second embodiment will be described referring to Fig.8.

[0031] The modulator module 52 includes a photo-modulator 53 having substantially same configuration as that of the first embodiment and a non-spherical surface lens 54 jointly having a single optical axis with the photo-modulator 53 overlying a sub-mount 51. The light of the photo-modulator 53 is incident through the non-spherical surface lens 54 on an optical fiber 55 an end of which is fixed to the end of the sub-mount 51. The modulator module 52 of the embodiment easily forms optical modulation signals with lower chirping.

[0032] Since the above embodiment is described only for examples, the present invention is not limited to the above embodiment and various modifications or alterations can be easily made therefrom by those skilled in the art without departing from the scope of the present invention.

Claims

1. An optical device comprising:

   a substrate;
   a distributed feedback (DFB) semiconductor laser (30) formed on the substrate (11) and including a diffraction grating (13) having an asymmetrical λ /4 phase shift region (14), the diffraction grating (13) extending along an optical axis of the DFB semiconductor laser (30); and
   a field absorbing modulator (40) integrated with the DFB semiconductor laser (30) on the substrate (11) for modulating a light wave emitted from the DFB semiconductor laser (30) **characterized in that**:
   the modulator (40) has a facet reflection rate between 0.01 and 0.02 % at an output end thereof, and the diffraction grating (13) has a κ L value between 1 and 1.2.

2. An optical modulator comprising the optical device as defined in claim 1 as a built-in light source.

3. An optical device comprising:

   a substrate;
   a distributed feedback (DFB) semiconductor laser (30) formed on the substrate (11) and including a diffraction grating (13) having an asymmetrical λ /4 phase shift region (14), the diffraction grating (13) extending along an optical axis of the DFB semiconductor laser (30); and
   a field absorbing modulator (40) integrated with the DFB semiconductor laser (30) on the substrate (11) for modulating a light wave emitted from the DFB semiconductor laser (30) **characterized in that**:
   the modulator (40) has a facet reflection rate between 0.02 and 0.03 % at an output end thereof, and the diffraction grating (13) has a κ L value between 1.2 and 1.3.

4. An optical modulator comprising the optical device as defined in claim 3 as a built-in light source.

5. An optical device comprising:

   a substrate;
   a distributed feedback (DFB) semiconductor laser (30) formed on the substrate (11) and including a diffraction grating (13) having an asymmetrical λ /4 phase shift region (14), the diffraction grating (13) extending along an optical axis of the DFB semiconductor laser (30); and
   a field absorbing modulator (40) integrated with the DFB semiconductor laser (30) on the substrate (11) for modulating a light wave emitted from the DFB semiconductor laser (30) **characterized in that**:
   the modulator (40) has a facet reflection rate between 0.03 and 0.05 % at an output end thereof, and the diffraction grating (13) has a κL value between 1.3 and 1.4.

6. An optical modulator comprising the optical device as defined in claim 5 as a built-in light source.

7. An optical device comprising:

   a substrate;
   a distributed feedback (DFB) semiconductor laser (30) formed on the substrate (11) and including a diffraction grating (13) having an asymmetrical λ /4 phase shift region (14), the diffraction grating (13) extending along an optical axis of the DFB semiconductor laser (30); and
   a field absorbing modulator (40) integrated with the DFB semiconductor laser (30) on the sub-

strate (11) for modulating a light wave emitted from the DFB semiconductor laser (30) **characterized in that**:

the modulator (40) has a facet reflection rate between 0.05 and 0.1 % at an output end thereof, and the diffraction grating (13) has a κL value between 1.4 and 1.7.

8. An optical modulator comprising the optical device as defined in claim 7 as a built-in light source.

FIG. 1
PRIOR ART

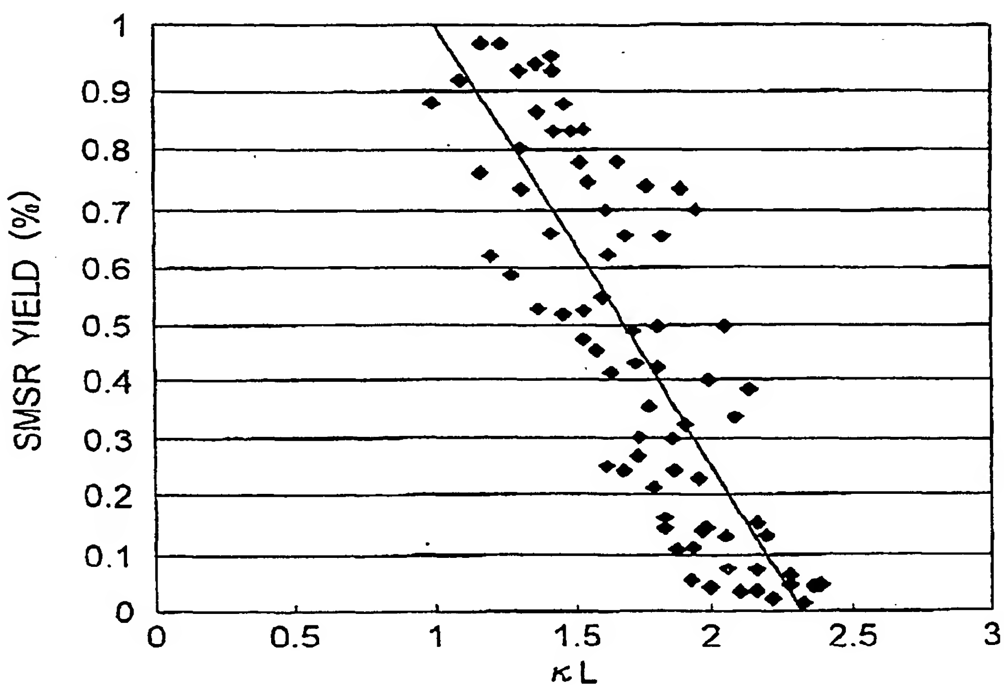


FIG. 2

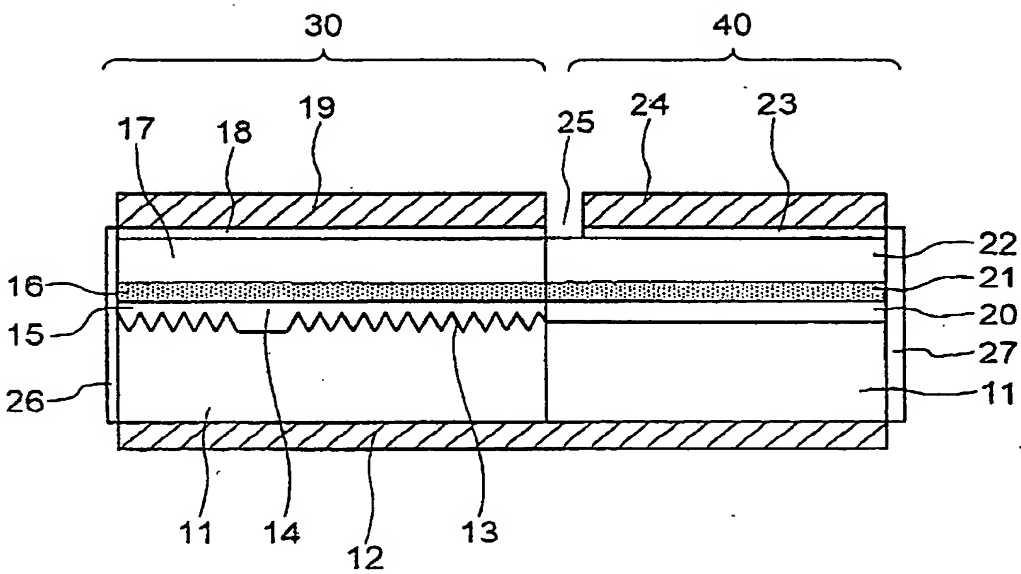
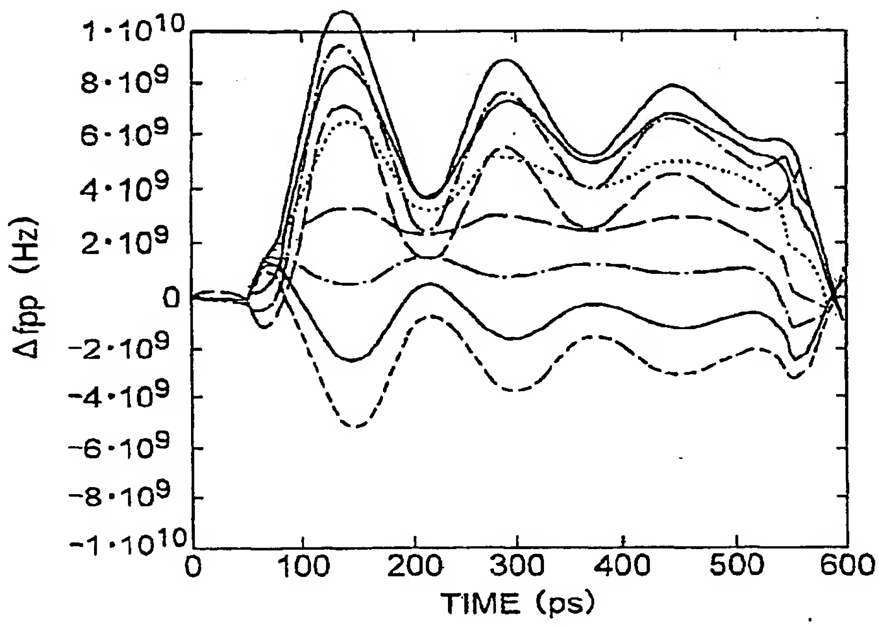


FIG. 3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-1·10^10
Δfpp (Hz)
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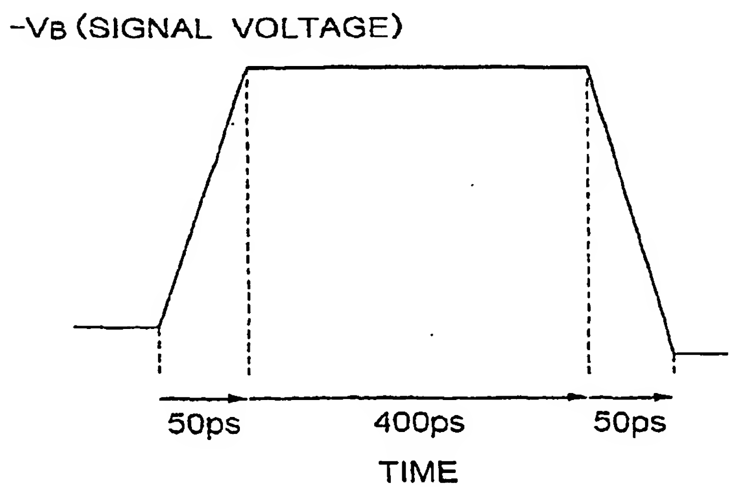
100
200
300
400
500
600
TIME (ps)

FIG. 4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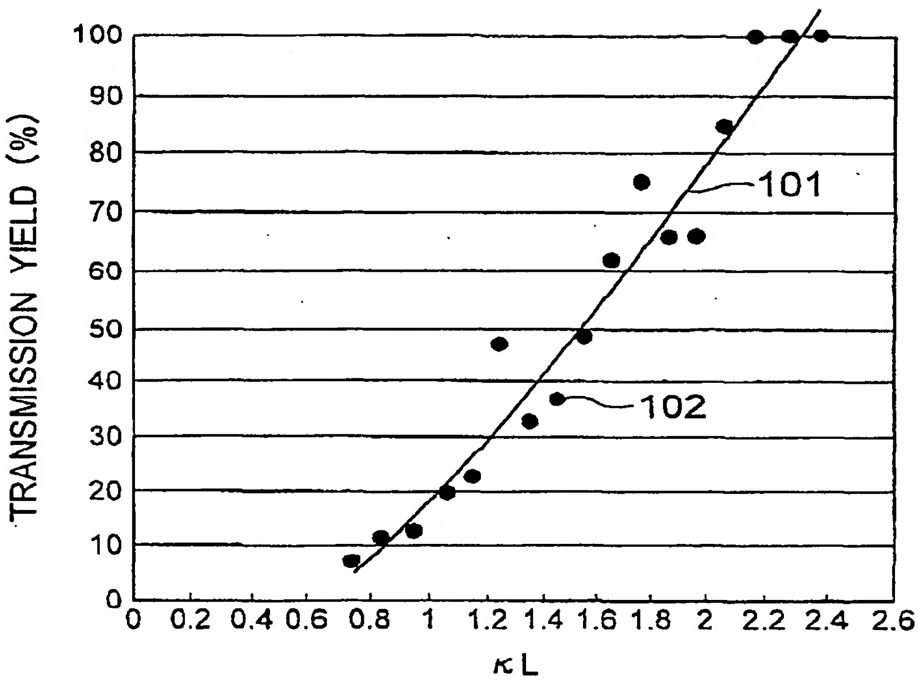
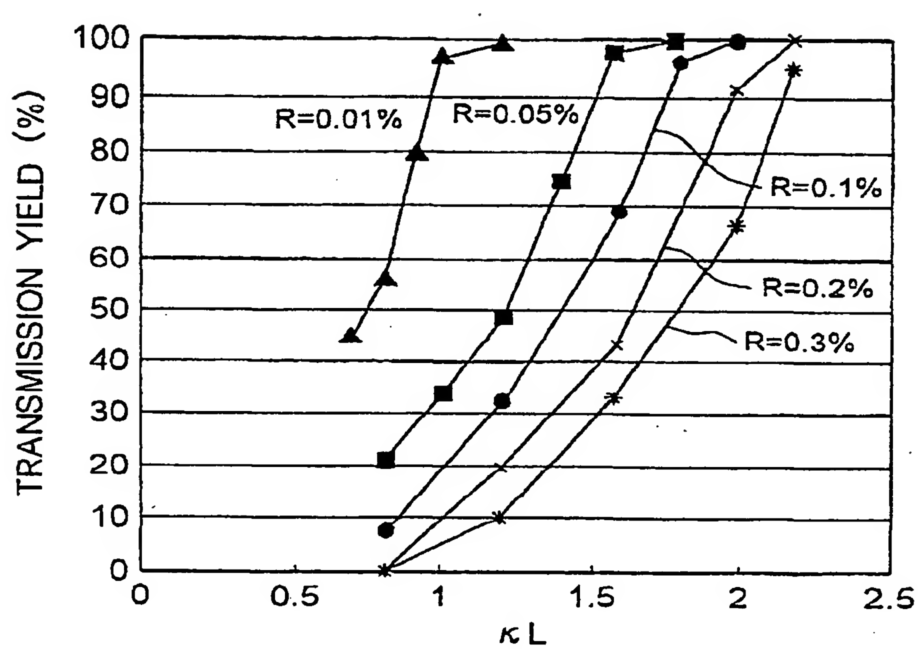
50ps
TIME

FIG. 5



TRANSMISSION YIELD (%)
100
90
80
70
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
κL
101
102

FIG. 6


TRANSMISSION YIELD (%)
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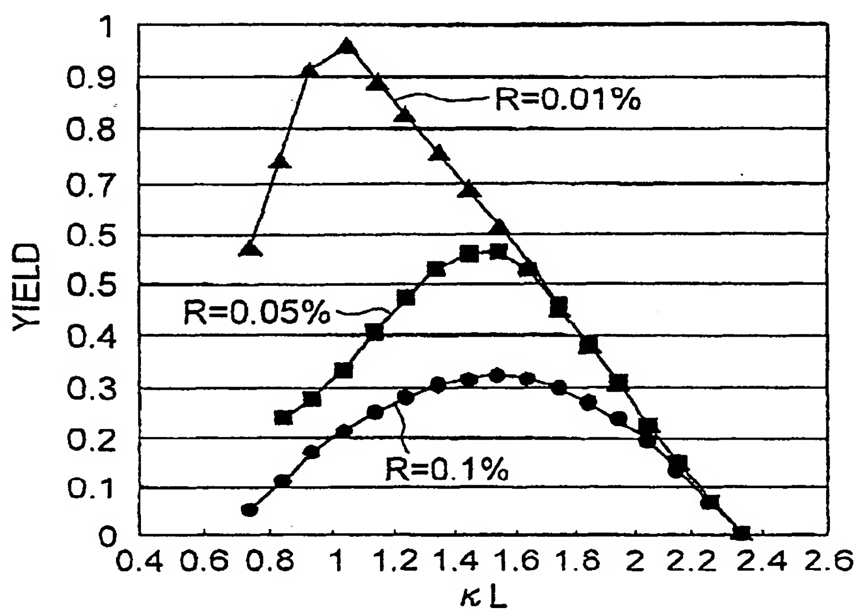
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
κL
R=0.01%
R=0.05%
R=0.1%
R=0.2%
R=0.3%

FIG. 7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R=0.05%
R=0.1%
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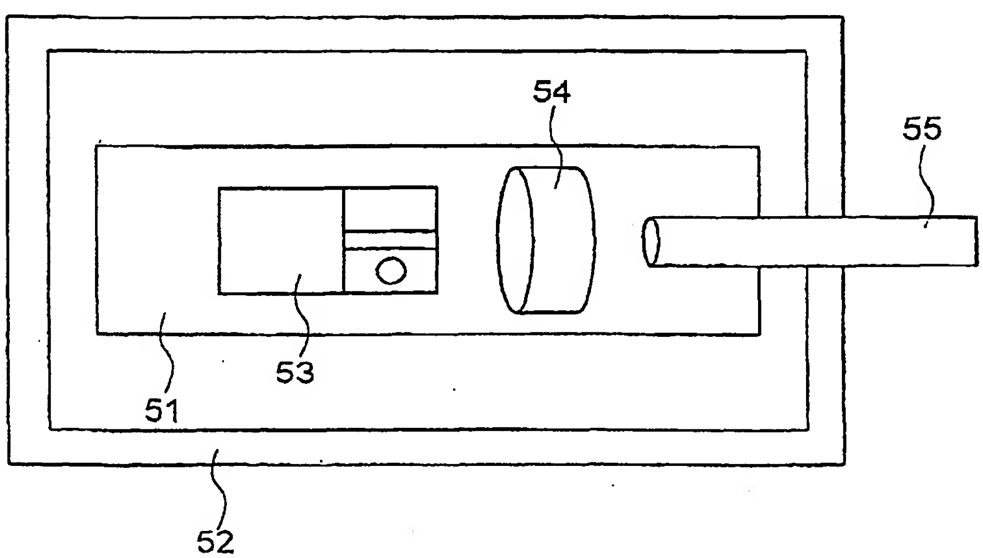
κL

FIG. 8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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 11 1372

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	YAMAGUCHI M ET AL: "REQUIREMENTS FOR MODULATOR-INTEGRATED DFB LD'S FOR PENALTY-FREE 2.5-GB/S TRANSMISSION" JOURNAL OF LIGHTWAVE TECHNOLOGY,US,IEEE. NEW YORK, vol. 13, no. 10, 1 October 1995 (1995-10-01), pages 1948-1954, XP000596072 ISSN: 0733-8724	7,8	H01S5/12 H01S5/026 G02F1/025
A	* the whole document *	1-6	
Y	KOTAKI Y ET AL: "ANALYSIS OF STATIC AND DYNAMIC WAVELENGTH SHIFTS IN MODULATOR INTEGRATED DFB LASERS" PROCEEDINGS OF THE EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION (ECOC),CH,ZURICH, SEV, vol. CONF. 19, 12 September 1993 (1993-09-12), pages 381-384, XP000492242	7,8	
A	* the whole document *	1-8	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	SAHLEN O: "OPTIMIZATION OF DFB LASERS INTEGRATED WITH FRANZ-KELDYSH ABSOPRTIONMODULATORS" JOURNAL OF LIGHTWAVE TECHNOLOGY,US,IEEE. NEW YORK, vol. 12, no. 6, 1 June 1994 (1994-06-01), pages 969-976, XP000484213 ISSN: 0733-8724 * the whole document *	1-8	H01S G02F

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	23 July 2001	Kiernan, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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